US Fish and Wildlife Service Bull Trout Workshop

Yakima Basin Case History for Bull Trout (*Salvelinus confluentus*)

US Fish and Wildlife Service
Columbia River Fisheries Program Office
9317 NE Highway 99, Suite I
Vancouver, Washington 98665

www.r1.fws.gov/crfpo

Introduction:

The following case history for the Yakima River has been developed to provide some background and context for exploring bull trout monitoring and evaluation issues. The document provides information on the geography, bull trout biology, historic and current distribution, and reasons for decline. As part of the Columbia River Distinct Population Segment (DPS), the Yakima River encompasses the entire Middle Columbia River Recovery (Lohr et al 2000). The Middle Columbia Recovery Unit represents a relatively complex and data poor system for bull trout.

The Yakima River Basin is located in south central Washington. Major tributaries include the Naches, Kachess, Cle Elum, and Teanaway rivers, as well as Toppenish, Satus, and Ahtanum creeks (Figure 1). Of the five major storage reservoirs in the basin (Kachess, Keechelus, and Cle Elum, Bumping, and Rimrock), all but Rimrock, created by Tieton Dam on the Tieton River, were historically natural lakes. A major portion of the basin overlaps ceded lands of the Yakama Nation.

The historic distribution and abundance of bull trout within the basin is unknown. However, given the intensive development and fragmentation of the basin by tributary impoundments it is likely that bull trout were historically more wide spread and abundant than currently observed. Current distribution of bull trout includes the Yakima River, Ahtanum Creek, Naches River, Rimrock Lake, Bumping Lake, North Fork Teanaway River, Cle Elum/Waptus Lakes, Kachess Lake, and Keechelus Lake.

Geographic Description:

The Yakima River Basin is located in south central Washington, draining approximately 6,155 square miles (Figure 1). The basin occupies most of Yakima and Kittitas Counties, about half of Benton County and a small portion of Klickitat County. It is bounded on the west by the Cascade Range, on the north by the Wenatchee Mountains, on the east by the Rattlesnake Hills, and on the south by the Horse Heaven Hills. Basin lands are some of the most intensively irrigated in the United States with approximately 465,000 irrigated acres. Other major land use activities include livestock operations (grazing, feedlots, dairies) and timber production/harvest. The Yakima River flows southeasterly for about 215 miles from its headwaters in the Cascades to its confluence with the Columbia River near Richland, Washington. Altitudes in the basin range from 8,184 feet above mean sea level in the Cascades to 340 feet at the confluence. The Naches River is the largest tributary of the Yakima, flowing 45 miles to its confluence at the city of Yakima. The Naches forms at the confluence of the Bumping, American, and the Little Naches rivers. Its major tributaries are Rattlesnake Creek and the Tieton River. Major tributaries of the upper Yakima River (above the Naches confluence) include the Kachess, Cle Elum, and Teanaway rivers. The major tributaries of the lower Yakima River include Toppenish and Satus creeks, both originating on the Yakama Indian Reservation, and Ahtanum Creek. Numerous smaller streams contribute seasonal flows to the rivers in the basin. The climate of the Yakima River basin ranges from alpine along the crest of the Cascade Range to arid in the lower valleys. The mountainous western and northern parts of the basin receive precipitation principally as snow from November through March and as rain during the remainder of the year. The eastern portion of the basin receives some snowfall but the majority of the precipitation falls as rain between October and March. Precipitation varies considerably across the basin throughout the year. Mean-annual accumulations range from about 130 inches in the higher elevations of the mountains to less than 8 inches in the far eastern half of the basin (SOAC 1999).

In general, summer air temperatures are warm in the mountains to hot in the lower elevation areas of the basin. Winters are cold throughout the basin. Minimum and maximum mean-monthly temperatures occur in January and in July, respectively. For the period between 1931 and 1977, mean monthly air temperatures in January ranged from 24 to 31 degrees Fahrenheit throughout the basin with a single day minimum of -33 degrees Fahrenheit recorded on January 31, 1950. Mean monthly air temperatures for July during this same period ranged from 63 to 77 degrees Fahrenheit with a single day maximum of 110 degrees Fahrenheit recorded on August 17, 1977.

There are five major storage reservoirs in the Yakima Basin. Keechelus, Kachess, and Cle Elum reservoirs are located in the upper Yakima Basin. Bumping and Rimrock reservoirs are located in the upper Naches River. These reservoirs have a total storage capacity of about 1.1 million acre-feet. In addition, there are numerous irrigation diversion dams. In combination, this development has significantly altered the natural hydrographs of the rivers in the Yakima Basin. Basin hydrographs are now generally characterized by much lower than normal winter flows as water is stored for the next year's use and much higher than normal summer flows as water is delivered in-channel to various diversion points for irrigation. During the run-off period in the spring, high flows still occur during most years but the magnitude of these flows is greatly reduced over those which would have occurred naturally. During the winter and early spring, high flows may also occur when water is released from the reservoirs during flood control operations. The annual estimated unregulated runoff of the Yakima River at Parker (in the lower river) averages 3.5 million acre-feet (SOAC 1999). The average annual irrigation diversion requirements are approximately 2.2 million acre-feet. Approximately 375,000 acre-feet returns as irrigation return flow in a normal water year (USBR 1999).

Most of the Yakima River and its tributaries are classified as Class A (excellent) as defined under water quality criteria for surface waters in the State of Washington. The Yakima River above the Cle Elum River, the upper Naches River, and the Tieton River are classified as Class AA (extraordinary). Water quality degrades significantly in downstream reaches of the Yakima River. Human activities have created point and non-point sources of contaminants which affect water quality. More than 70 percent of the irrigated land, 90 percent of the point source and non-point source nutrient loads, and more than 80 percent of the human population are located in the middle and lower Basin areas downstream from the Kittitas Valley.

Biology:

Little specific information exists on the biology of bull trout in the Yakima Basin. The basin has been heavily developed for agricultural purposes. The five tributary dams within the basin allow for intensive water management and delivery. As a result of these activities, the basin is highly fragmented. Adfluvial populations of bull trout persist in each of the reservoirs. Fluvial populations of bull are documented below these facilities, but their status and distribution is unclear. Similarly, resident forms also can be found within the basin, but their status and distribution are also unknown.

Spawning within the basin occurs from late August through early October. Little specific information exists regarding age at maturity, sex ratio, fecundity, timing of fry emergence, and survival rates. Within the Naches River, spawning location and timing information is available only for Rattlesnake Creek and the American River. Most spawning probably occurs in September and spawners range in size from 200 to 457 millimeters in Rattlesnake Creek. Larger fish, greater than 500 millimeters, have been observed spawning in the American River.

In Rimrock Lake, spawning occurs in Indian Creek and the South Fork Tieton River from late August to early October. Bull trout appear to stage in the South Fork Tieton as early as June and July. Bull trout also spawn in Bear Creek, a tributary of the South Fork Tieton. Although bull trout are present in the North Fork Tieton River below Clear Lake Dam, spawning activity has not been observed. The majority of adult spawners range from 457 to 610 millimeters in total length. However, fish from 200 to 800 millimeters have been observed during spawning surveys and trap monitoring. Juvenile bull trout have been observed in several other South Fork Tieton tributaries including Short, Dirty, Grey, Spruce and Corral creeks. In the last four years, the Washington Department of Fish and Wildlife (WDFW) has been working with Central Washington University to monitor bull trout in Rimrock Lake. Based upon initial indications of run timing and tagging work, it appears that Indian Creek and South Fork Tieton fish may be two distinct spawning populations.

Spawning in Deep Creek (tributary to Bumping Lake) occurs from late August to mid-September and the majority of adult spawners range from 457 to 610 millimeters mm in total length (although larger fish have been observed during spawning surveys).

In the Kachess River, above the dam, spawning occurs from early September to early October in Box Canyon Creek, although some bull trout can be observed holding in the deeper pools in late August. The majority of adult spawners range from 457 to 610 millimeters in total length, although larger fish have been observed during spawning surveys. Very little information is available on the age composition of the spawning population and only a few fish have been aged.

Within the Ahtanum Creek system, bull trout spawning occurs in September and has been observed in the North and Middle forks Ahtanum Creek and in Shellneck Creek a small tributary of the upper North Fork. The majority of adult spawners range from 200 to 356 millimeters in total length.

Adfluvial bull trout originating from Keechelus Lake spawn in Gold Creek from early September to early October. Most fish probably enter the creek in early August and hold in the deeper pools, but some fish may enter as much as a month or two earlier. Anecdotal accounts suggest that bull trout were present in Rocky Run Creek in the early 1980s, but there have been no recent surveys to confirm their presence. The majority of adult spawners range from 457 to 610 millimeters in total length, although fish as small as 200 millimeters have been observed on redds. Limited information indicates the age composition of the spawning population is four to ten years of age with a sex ratio of 1:1 and fecundity of several thousand eggs per adult female (Anderson, E. pers. in litt.. 2001b). Timing of fry emergence likely occurs in March and rearing juveniles probably spend several years in Gold Creek before migrating to Keechelus Lake.

Distribution and Abundance

Status of Bull Trout at the Time of Listing

Eight bull trout populations were identified in the Yakima River basin (USFWS 1998). These populations included; Ahtanum Creek, Naches River, Rimrock Lake, Bumping Lake, North Fork Teanaway River, Cle Elum Lake, Kachess Lake, and Keechelus Lake. At the time of listing (June 1998), only the Rimrock Lake population was considered stable and increasing. The remaining populations were classified as depressed and declining. The population trend for the Naches River population was classified as unknown. With the exceptions of the Rimrock Lake and Naches River, the remaining populations were considered to be at risk of extirpations due to natural events.

Current Distribution and Abundance

In the past, wild bull trout occurred throughout the Yakima River, but they are now fractured into isolated populations. Although bull trout were probably never as abundant as other salmonids in the Yakima basin, they were certainly more abundant and more widely distributed than they are today. Currently, 13 local populations of bull trout have been identified and include Ahtanum Creek (including North, South, and Middle forks), Rattlesnake Creek, American River, Crow Creek, South Fork Tieton River, Indian Creek, North Fork Teanaway River, Deep Creek, Box Canyon Creek, Upper Kachess River, Gold Creek, Upper Cle Elum River, and Upper Yakima Mainstem (Keechelus to Easton). While no long-term systematic surveys of bull trout in the Upper Cle Elum and Upper Mainstem Yakima have been conducted, biologists believe that recent sightings in each area warrant inclusion as local populations. All bull trout local populations in the Yakima basin are native fish sustained by wild production, as there are no hatchery bull trout stocks in Washington state. There is no information to indicate whether these are genetically distinct stocks. The WDFW in cooperation with the U.S. Forest Service (USFS) and the Yakima Nation conduct annual bull trout spawning ground surveys in selected locations within the basin (Table 1). This information represents the best census information available for distribution and abundance within the Yakima River.

Yakima River

Yakima bull trout inhabit the upper mainstem Yakima River from Roza Dam upstream to the upper reservoir dams (Cle Elum, Kachess and Keechelus dams). Bull trout were probably extirpated in the lower Yakima River many years ago, probably before the 1950s.(Anderson, E. pers. comm 2001a). Although one bull trout was encountered by WDFW research biologists in 1997 in the lower river near Benton City .

Old catch records, some dating to the 1930s, indicate the presence of small numbers of bull trout in Yakima River tributaries including Satus Creek, Cowiche Creek, Coleman Creek and the Cle Elum River. The fish caught in Cowiche and Satus creeks may have been strays or misidentified brook trout. It is unknown whether or not bull trout still occur in Coleman Creek or in the Cle Elum River below Cle Elum Lake Dam.

Bull trout in the Yakima River are considered to be fluvial, however, in May, 1996 one 545 millimeter bull trout was illegally caught in Easton Lake a 238-acre reservoir of the upper Yakima River. It is unknown whether or not this fish belonged to an isolated adfluvial population in the lake, or was a fluvial fish. The few fish that have been caught in recent years range in size from 305 to 559 millimeters. Only a few bull trout have been found since intensive field monitoring of trout populations in the upper Yakima River mainstem began in 1990. Electrofishing surveys conducted annually during September and October between Roza Dam and Cle Elum have turned up only two bull trout in the Yakima River (one near Cle Elum and one near Ellensburg). In 1993, a single bull trout was captured in a trap in Swauk Creek, near the confluence with the Yakima River (Anderson, E. in litt. 2001a).

Index areas for redd counts are not fully established in the Yakima River. A single pass snorkel/foot survey conducted on Sept. 14, 2000 in the Keechelus Dam to Easton Lake reach identified two bull trout redds (Anderson, E. in litt. 2001c). Large (24-30 inch) bull trout were tending the redds located in the braided area around Crystal Springs. Spring chinook salmon were also spawning in the area. Without the benefit of seeing bull trout actively spawning or tending redds, bull trout redds could easily have been identified as chinook redds. Additional surveys are needed in this and other Yakima River reaches, particularly below dams (e.g., Cle Elum, Bumping rivers) and other areas with significant groundwater upwelling.

Ahtanum Creek

Bull trout in Ahtanum Creek most likely originated from native fluvial/resident life history forms that occurred throughout the Yakima River. Currently, they are probably isolated from fish in the Yakima River due to thermal barriers and total dewatering (July-October) of lower Ahtanum Creek below river mile 19.7 at Wapato Irrigation Diversion. Bull trout have been encountered below this diversion during mid-April when water is available. Although bull trout are present in the mainstem Ahtanum Creek, they are probably more abundant in the upper portion of the drainage, particularly in the North and Middle and South forks where habitat conditions are more favorable. Recent snorkel surveys by Dunham and Chandler (2001) identified the presence of bull trout in the North and Middle forks of Ahtanum Creek. Juvenile and adult bull trout were found at low densities in the Middle Fork. Surveys found only juveniles, also at low densities, in the North Fork Ahtanum drainage. Bull trout were not found in surveys conducted at sites in the South Fork Ahtanum Creek.

Naches River

Naches bull trout inhabit the Tieton River (below Rimrock Lake/Tieton Dam), Rattlesnake Creek, American River, Little Naches River, the Bumping River (below Bumping Lake Dam), and small tributaries of these larger streams including Dog, Hindoo, Little Wildcat and North Fork Rattlesnake creeks (Rattlesnake Creek drainage), Crow, Quartz and Pileup Creeks (Little Naches River drainage), Kettle, Timber and Union creeks (American River drainage). Recent USFS surveys have found one bull trout in Oak Creek and one in Milk Creek (Anderson, E. in litt. 2001a).

Bull trout in the Naches River originated from native fluvial/resident life history forms. Although only a few fluvial bull trout have been encountered in the upper Yakima River mainstem, they continue to persist, with the resident life history form, in the Naches River drainage where habitat conditions are more favorable. With the exception of dams on the upper Bumping and upper Tieton rivers which block fish passage, bull trout are able to migrate freely within the Naches River drainage.

Rimrock Lake

Rimrock Lake bull trout inhabit Rimrock Lake and its tributaries above the Tieton Dam. The primary spawning locations are in the South Fork Tieton River and Indian Creek. These bull trout originated from native fluvial/resident fish in the Tieton River, but construction of the dam in 1925, forced bull trout to adopt a adfluvial life history pattern. Recent electrofishing surveys conducted in Indian Creek collected 140 bull trout ranging in size from 70-300 mm (Polos, J. pers comm. 2001).

Old catch records reported bull trout in Clear Lake on the North Fork Tieton throughout the 1950s, but few have been caught since then. However, in 1993 USFS staff reported capturing one 75 to 100 millimeters bull trout from a minnow trap in Clear Lake, and in 1996 biologists from Central Washington University observed an adult bull trout in the upper North Fork Tieton River (Anderson, E. in litt. 2001a).

Bumping Lake

Bull trout inhabit Bumping Lake and its tributaries above Bumping Lake Dam. Deep Creek appears to be the primary tributary of Bumping Lake where bull trout spawn. The USFS reported a single redd with three bull trout in the upper Bumping River in 1994 (Lindhorst, K. pers. comm. 2001). Recent electrofishing surveys collected 23 bull trout from 100-300 mm in length (Polos, J. pers. comm. 2001). Bull trout in Bumping Lake may have originated from a native adfluvial life history form which was present even before the construction of the dam in 1910. Fluvial and resident forms may have been present as well since they currently inhabit streams in the drainage below Bumping Lake Dam. Construction of the dam enlarged the natural lake and forced any fluvial bull trout to adopt an adfluvial life history.

North Fork Teanaway River

Bull trout have been observed in the North Fork Teanaway and small tributary streams including Jungle, Jack, and DeRoux creeks. Although the habitat appears to be suitable for bull trout in the West and Middle forks, no bull trout have been found in these streams. Bull trout appear to be more abundant in the North Fork Teanaway than in other upper Yakima River tributaries. Even so they are still at extremely low levels of abundance. Bull trout in the North Fork may be a mix of both small resident forms and larger fluvial forms that migrate from the Yakima River. Until recently it was thought that this was strictly a isolated resident population, but a few larger bull trout have been recently observed in the North Fork Teanaway River Presumably, these larger forms are fish that migrate from the Yakima River.

Cle Elum and Waptus Lake

Bull trout inhabit Cle Elum Lake and its tributaries above Cle Elum Lake Dam, and Waptus Lake and its tributaries in the headwaters of the Cle Elum drainage. They may have originated from a native adfluvial life history form which was present even before the construction of the dam in 1931. The fluvial form may have been present in the area as well, although currently very few are encountered in the mainstem Yakima River below the Cle Elum drainage. Construction of the dam enlarged the natural lake and forced any fluvial bull trout stock to adopt an adfluvial life history pattern.

The National Marine Fisheries Service captured 17 fish (150 to 400 millimeters) in traps set in Cle Elum Lake from 1990 to 1993 (Anderson, E. in litt. 2001a). In 1996, biologists from Central Washington University observed several adult bull trout in the upper Cle Elum River in late August. Old catch records indicate that bull trout were present in Waptus Lake in the 1940s and early 1950s (Anderson, E. in litt. 2001a). Washington Department of Fish and Wildlife biologists recently confirmed the presence of bull trout in Waptus Lake by capturing a single juvenile fish from a gill net in 1996. Biologists also captured and released a large adult by hook-n-line in 1997. Recently, biologists working in the upper Cle Elum River drainage discovered redds below Hyas Lake (Anderson, E. in litt. 2001c). Although fish were not observed, the redds were of a large size and presumably constructed by large adfluvial bull trout from Cle Elum Lake. It is not known what relationship, if any, exits between bull trout inhabiting Waptus and Cle Elum lakes. A falls located on the lower Waptus River between Waptus and Cle Elum lakes may serve as a barrier to bull trout migration between the two systems.

Kachess Lake

Bull trout inhabit Kachess Lake and its tributaries above Kachess Lake Dam. Adult spawning in the Kachess River occurs primarily in Box Canyon Creek. However, some spawning may also occur in the upper Kachess River and in Mineral Creek when adequate flows are available. Although bull trout have been observed in the latter two streams, there are no data to confirm spawning activity and additional survey information is needed. They may have originated from a native adfluvial life history form which was present in the existing lake even before the construction of the dam in 1905. Fluvial forms may have been present in the area as well, although currently very few are encountered in the mainstem Yakima River below the Kachess drainage.

Keechelus Lake

Bull trout inhabit Keechelus Lake and its tributaries above Keechelus Lake Dam on the upper Yakima River. They originated from a native adfluvial life history form which was present even before the construction of the dam in 1914. Construction of the dam turned the former natural lake into a large irrigation storage reservoir. Adfluvial bull trout originating from Keechelus Lake spawn in Gold Creek from early September to early October. Most fish probably enter the creek in early August and hold in the deeper pools, but some fish may enter as much as a month or two earlier. Anecdotal accounts suggest that bull trout were present in Rocky Run Creek in the early 1980s, but there have been no recent surveys to confirm their presence.

Table 1. Annual summary of bull trout spawning surveys in the Yakima core area, 1984 - 2001 (number of redds/year in index areas; by stock and stream), ® = Resident, F = Fluvial, F/R = Fluvial/Resident, AD = Adfluvial). Wa. Dept Fish & Wildlife files, Region 3, Yakima, WA.

Stream	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Ahtanum Creek (R)																	
N.F. Ahtanum Cr. (Shellneck Cr.)	____	____	____	____	____	____	____		____	9	14	6	5	7	5	7	11
M.F. Ahtanum Cr.	____	____	____	____	____	____	____	____	____	____	____	____	1	1	____	____	10*
S.F. Ahtanum Cr.	____	____	____	____	____	____	____	____	____	____	____	____	____	____	____	____	5*
Naches River (F/R)																	
Rattlesnake Cr. (Little Wildcat Cr.)	____	____	____	____	____	____	2*	____	____	____	4*	26*	46	53	44	45	
American R. (Union and Kettle Cr.)	____	____	____	____	____	____	____	____	____	____	____	____	24	31	30	44	
Crow Cr.	____	____	____	____	____	____	____	____	____	____	____	____	____	____	____	19	26
Rimrock Lake (AD)																	
S.F. Tieton R. (Bear Cr.)	____	____	____	____	____	____	32*	____	____	38	167	95	233	177	142	161	144
Indian Cr.	29*	69*	16*	35*	25	39	69	123	142	140	179	201	193	193	212	205	226
Bumping Lake (AD)																	
Deep Cr.	____	____	____	____	____	17	15	84	78	45	12	101	46	126	98	107	147
N.F. Teanaway River (F/R)																	
DeRoux Cr.	____	____	____	____	____	____	____	____	____	____	____	____	2	0	0	____	0*
Kachess Lake (AD)																	
Box Canyon Cr.	5	4	3	0	0	0	5	9	5	4	11	4	8	10	16	17	10
Upper Kachess R.	____	____	____	____	____	____	____	____	____	____	____	____	____	____	0*	____	0*
Keechelus Lake (AD)																	
Gold Cr.	2	2	21	15	12	3	11	16	14	11	16	13	51	31	36	40	19

* An asterisk next to a redd count indicates an incomplete or inconsistent survey.
Annual summary of bull trout spawning surveys in the Yakima , 1984 - 2000.

Essential Habitat Characteristics for Bull Trout:

Bull trout have more specific habitat requirements than most other salmonids (Rieman and McIntyre 1993). Habitat components that influence bull trout distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrate, and migratory corridors (Fraley and Shepard 1989; Goetz 1989; Hoelscher and Bjornn 1989; Sedell and Everest 1991; Howell and Buchanan 1992; Pratt 1992; Rieman and McIntyre 1993, 1995; Rich 1996; Watson and Hillman 1997). Watson and Hillman (1997) concluded that watersheds must have specific physical characteristics to provide habitat requirements for bull trout to successfully spawn and rear, and that the characteristics are not necessarily present throughout these watersheds. Because bull trout exhibit a patchy distribution, even in pristine habitats (Rieman and McIntyre 1993), fish should not be expected to simultaneously occupy all available habitats (Rieman *et al.* 1997b).

Migratory corridors link seasonal habitats for all bull trout life histories. For example, in Montana, migratory bull trout make extensive migrations in the Flathead River system (Fraley and Shepard 1989), and in tributaries of the Bitterroot River, resident bull trout move downstream to overwinter in tributary pools (Jakober 1995). The ability to migrate is important to the persistence of bull trout (Rieman and McIntyre 1993; M. Gilpin, University of California, *in litt.* 1997; Rieman *et al.* 1997b). Migrations facilitate gene flow among local populations when individuals from different local populations interbreed, stray, or return to non-natal streams. Local populations that are extirpated by catastrophic events may also become reestablished by bull trout migrants.

Bull trout are found primarily in colder streams, although individual fish are found in larger, warmer, river systems throughout the Columbia River basin (Fraley and Shepard 1989; Rieman and McIntyre 1993, 1995; Buchanan and Gregory 1997; Rieman *et al.* 1997b). Water temperature above 15 degrees Celsius (59 degrees Fahrenheit) is believed to limit bull trout distribution, which may partially explain the patchy distribution within a watershed (Fraley and Shepard 1989; Rieman and McIntyre 1995). Spawning areas are often associated with cold-water springs, groundwater infiltration, and the coldest streams in a given watershed (Pratt 1992; Rieman and McIntyre 1993; Rieman *et al.* 1997b; Baxter *et al.* 1999). Goetz (1989) suggested optimum water temperatures for rearing of about 7 to 8 degrees Celsius (44 to 46 degrees Fahrenheit) and optimum water temperatures for egg incubation of 2 to 4 degrees Celsius (35 to 39 degrees Fahrenheit). In Granite Creek, Idaho, Bonneau and Scarnecchia (1996) observed that juvenile bull trout selected the coldest water available in a plunge pool, 8 to 9 degrees Celsius (46 to 48 degrees Fahrenheit) within a temperature gradient of 8 to 15 degrees Celsius (46 to 60 degrees Fahrenheit). In Nevada, adult bull trout have been collected at 17.2 degrees Celsius (63 degrees Fahrenheit) in the West Fork of the Jarbidge River (S. Werdon, Fish and Wildlife Service, *pers. comm.* 1998); and observed in Dave Creek where maximum daily water temperatures were 17.1 to 17.5 degrees Celsius (62.8 to 63.6 degrees Fahrenheit) (S. Werdon, Fish and Wildlife Service, *in litt.* 2001). In the Little Lost River, Idaho, bull trout have been collected in water up to 20 degrees Celsius (68 degrees Fahrenheit), however, they made up less than 50 percent of all salmonids when maximum summer water temperature exceeded 15 degrees Celsius (59 degrees Fahrenheit) and less than 10 percent of all salmonids when temperature exceeded 17 degrees Celsius (63 degrees Fahrenheit) (Gamett 1999).

All life history stages of bull trout are associated with complex forms of cover, including large woody debris, undercut banks, boulders, and pools (Fraley and Shepard 1989; Goetz 1989; Hoelscher and Bjornn 1989; Sedell and Everest 1991; Pratt 1992; Thomas 1992; Rich 1996; Sexauer and James 1997; Watson and Hillman 1997). Jakober (1995) observed bull trout overwintering in deep beaver ponds or pools containing large woody debris in the Bitterroot River drainage, Montana, and suggested that suitable winter habitat may be more restricted than summer habitat. Maintaining bull trout habitat requires stream channel and flow stability (Rieman and McIntyre 1993). Juvenile and adult bull trout frequently inhabit side channels, stream margins, and pools with suitable cover (Sexauer and James 1997). These areas are sensitive to activities that directly or indirectly affect stream channel stability and alter natural flow patterns. For example, altered stream flow in the fall may disrupt bull trout during the spawning period and channel instability may decrease survival of eggs and young juveniles in the gravel during winter through spring (Fraley and Shepard 1989; Pratt 1992; Pratt and Huston 1993).

Preferred spawning habitat consists of low gradient stream reaches with loose, clean gravel (Fraley and Shepard 1989) and water temperatures of 5 to 9 degrees Celsius (41 to 48 degrees Fahrenheit) in late summer to early fall (Goetz 1989). In the Swan River, Montana, abundance of bull trout redds was positively correlated with extent of bounded alluvial valley reaches, which are likely areas of groundwater-surface water exchange (Baxter *et al.* 1999). Survival of bull trout embryos planted in stream areas of groundwater upwelling used by bull trout for spawning were significantly higher than embryos planted in areas of surface-water recharge not used by bull trout for spawning (Baxter and McPhail 1999). Pratt (1992) indicated that increases in fine sediment reduce egg survival and emergence.

Bull trout typically spawn from August to November during periods of decreasing water temperatures. Temperatures during spawning generally range from 4 to 10 degrees Celsius (39 to 51 degrees Fahrenheit), with redds often constructed in stream reaches fed by springs or near other sources of cold groundwater (Goetz 1989; Pratt 1992; Rieman and McIntyre 1996). Migratory bull trout frequently begin spawning migrations as early as April, and have been known to move upstream as far as 250 kilometers (155 miles) to spawning grounds in Montana (Fraley and Shepard 1989; Swanberg 1997). In Idaho, bull trout moved 109 kilometers (67.5 miles) from Arrowrock Reservoir to spawning areas in the headwaters of the Boise River (Flatter 1998). In the Blackfoot River, Montana, bull trout began spring migrations to spawning areas in response to increasing temperatures (Swanberg 1997). Depending on water temperature, incubation is normally 100 to 145 days (Pratt 1992), and after hatching, juveniles remain in the substrate. Time from egg deposition to emergence may surpass 200 days. Fry normally emerge from early April through May depending upon water temperatures and increasing stream flows (Pratt 1992; Ratliff and Howell 1992).

Growth varies depending upon life-history strategy. Resident adults range from 150 to 300 millimeters (6 to 12 inches) total length and migratory adults commonly reach 600 millimeters (24 inches) or more (Pratt 1985; Goetz 1989). The largest verified bull trout is a 14.6 kilogram (32 pound) specimen caught in Lake Pend Oreille, Idaho, in 1949 (Simpson and Wallace 1982).

Bull trout are opportunistic feeders, with food habits primarily a function of size and life-history strategy. Resident and juvenile migratory bull trout prey on terrestrial and aquatic insects, macro-zooplankton and small fish (Boag 1987; Goetz 1989; Donald and Alger 1993). Adult migratory bull trout feed on various fish species (Leathe and Graham 1982; Fraley and Shepard 1989; Donald and Alger 1993; Brown 1992). In coastal areas of western Washington, bull trout feed on Pacific herring (*Clupea pallasi*), Pacific sand lance (*Ammodytes hexapterus*), and surf smelt (*Hypomesus pretiosus*) in the ocean (WDFW *et al.* 1997).

Reasons For Decline

Dams

A significant reason for the decline of bull trout populations in the Yakima Basin (Middle Columbia River Recovery Unit) is believed to be the dams constructed in the early 1900's to create the five major storage reservoirs for the Yakima Project and the numerous diversion dams constructed thereafter. Some diversion dams were in place prior to the construction of the storage dams but they were primitive and were reconstructed by the U. S. Bureau of Reclamation (USBR) as part of the Yakima Project. The impacts of both the storage and diversion dams are related both to the structures themselves as well as the operation of the facilities.

Of the five major storage reservoirs in the basin (Kachess, Keechelus, and Cle Elum, Bumping, and Rimrock), all but Rimrock, created by Tieton Dam on the Tieton River, were historically natural lakes. The dams built across the lake outlets greatly enlarged their surface area and flooded large areas of high quality fish habitat. None of these dams were constructed with fish passage facilities, a condition which still exists today. These dams isolated and fragmented local populations with a native adfluvial life history and prevented fluvial/resident populations in the Yakima and Naches drainages from reaching headwater spawning areas. The original diversion dams had crude passage facilities but they were very limited in their effectiveness and poorly maintained. Passage at these dams remained relatively ineffective even after reconstruction until the mid-1980's when modern passage facilities were constructed. While all now have effective passage facilities for the anadromous salmonids for which they were designed, it is unknown whether bull trout passage will be equally accommodated. The fish ladder at the Easton Diversion Dam on the upper Yakima River is not currently operated from early May to mid-October after the first year of consecutive dry water years to prevent access by spring chinook salmon whose redds would sustain a high likelihood of being dewatered at the end of the irrigation season. This is an operational constraint implemented by the USBR, not a physical one, and it happens on average, about one year in ten.

Another structural concern relates to the outlet works of the storage dams, all of which are unscreened. Bull trout which enter these submerged intake structures would be subjected to a rigorous and potentially fatal flush to the river downstream. While bull trout mortality as a result of this has not been documented, dead kokanee have been found in the Tieton River below the dam and dead burbot have been observed on occasion below Cle Elum Dam. Both of these lacustrine species had undoubtedly been entrained in the respective outlet works, giving good cause to conclude that bull trout might be as well.

The final structural issue which may have contributed to the decline of bull trout relates to the temperature of water released from the reservoirs during the summer and fall. Elevated water temperatures in some years have delayed the onset of spring chinook spawning in the upper Yakima River. Spawning activities for this species in the upper Yakima usually commence around mid-September when water temperatures are around 13-15 degrees Celsius, at the upper end of the suitability range for bull trout. In 1998, this temperature range was not attained until early October. The historic thermal regimes below the natural lakes in the basin are unknown but altered temperature regimes below dams are common. In many instances water temperatures are colder than occurred naturally but this is usually not the case below dams constructed near the headwaters. Limnological studies conducted by the USBR have shown temperature stratification to some degree in all of the storage reservoirs in the basin. Although none of the outlet works for these dams are surface release, all but those for Tieton Dam are located above the coldest waters available in the reservoir pool.

The operation of the dams in the Yakima Basin has had a profound effect on the flow regimes of the rivers in the basin and has likely contributed to the decline of bull trout populations. The magnitude of high flows resulting from rain-on-snow events and during the snowmelt runoff period have been reduced significantly (Figures 2-4). But it is the late summer/early fall hydrology in the upper portion of the basin which is probably most problematic for bull trout and in fact, the entire aquatic ecosystem. This is owed primarily to an operational procedure known as "flip-flop". Pursuant to a 1980 decision of the Federal District Court for the Eastern District of Washington, the Yakima Project is operated to protect incubating spring chinook salmon eggs and alevins in the upper Yakima River Basin. The Yakima, Cle Elum, and Tieton rivers are operated as a conduit to deliver irrigation water from April through mid-October. Through early September, most irrigation water is released from the reservoirs on the Yakima side of the basin (Keechelus, Kachess, and Cle Elum) with only minimal releases from the reservoirs on the Naches River side (Rimrock and Bumping). On or near September 10th, this release pattern is switched and late season irrigation demands are met from the Naches side for about a month and a half. Without going into further detail as to how this is biologically effective for the spring chinook salmon, the effect is to completely invert the flow regimes on both sides of the basin (Figures 2 and 5). The abnormally high flows in the upper Yakima River are reduced to levels very close to those which would occur in an unregulated river (Figure 2). On the Cle Elum River, where flows released from the largest reservoir in the basin have raged the entire summer, the effect is more profound as flows drop as much or more than an order of magnitude (Figure 6). In the Tieton River (Naches sub-basin) the effect is the opposite as flows increase four to five times over the level at which they were held most of the summer (Figure 7). The narrowly confined river channel conveys a white water torrent for practically its entire course. At the end of the irrigation season the Yakima Project goes into storage control and flows in the Tieton River are often reduced below 20 cubic feet per second. Flows are usually reduced on the Yakima side of the basin as well, sometimes as much as 50 percent, but they must remain adequate to protect spring chinook redds. On either side of the basin these unstable and abnormal flow patterns have undoubtedly had a negative impact on fluvial bull trout. Currently, successful spawning would be difficult at best in the upper Yakima and Cle Elum Rivers, and virtually impossible in the Tieton River.

Forest Management Practices

Forest management has likely contributed to degraded watersheds and habitat conditions in many watersheds within the recovery unit. Separating the effects on habitat or bull trout populations due to forest management (or any management activity) is difficult due to the extensive human use within Yakima basin. The following summarizes watersheds within the basin where forest management appears to be most contributing to degraded habitat conditions and therefore may be contributing to the decline of the bull trout population.

Upper Yakima Watershed

The Upper Yakima watershed has an extensive history of forest management. Twenty-six percent of the watershed is in an early seral (seedling/sapling) stage primarily from timber harvest (MacDonald and Mayo 1999). While there is no definitive threshold, it has been suggested that no more than 15-20 percent should be in a hydrologically immature stage at any one time (Spence et al 1996). The watershed is heavily roaded for timber harvest purposes with a road density of 3.6 miles per square mile (MacDonald and Mayo 1999). One example is Lower Cabin Creek where the channel is widening and bedload deposition appears to have increased, possibly due to roads, logging and increased peak flows in the subwatershed. A number of streams are on the 303(d) list for temperature including Big Creek, Cabin and Log creeks. Logging and roads in riparian habitat may be contributing to high summer stream temperatures. Fine sediment within spawning habitat exceeds 15 percent by volume in Cole, Gold, Little and Big creeks **(**Macdonald and Mayo 1999**)**.

Cle Elum Watershed

Timber harvest in the Cle Elum watershed began in 1909, with harvest in the early to mid 1950's centered around the east side of Cle Elum Lake. Harvest activities increased in the 1960's and centered on the west side of the lake. There was a slight decrease in timber harvest in the 1970's with another increase in the 1980's. By the 1990's harvest had dramatically decreased due to the listing of the spotted owl and the adoption of the Northwest Forest Plan in 1994 **(**Macdonald and Mayo 1999**)**. Much of the activity occurred in the lower watershed. Road densities in the Middle Cle Elum, Lower Cooper River and Thorp/French subwatersheds are greater than 2.4 miles per square mile. Past activities in these disturbed watersheds may be contributing to a lack of pools in the Cle Elum River, eroding banks and accelerated bedload deposition and unstable bars. Past wood removal and dispersed recreation are likely contributing factors as well (MacDonald 1999). Much of the upper portion of the watershed is in wilderness or lightly managed and natural watershed processes appear intact.

Swauk Watershed

The Swauk watershed has a long history of management activity starting with mining and grazing in the 1800's, timber harvest, highway construction, agriculture in the lower watershed and more recently recreation. While timber harvest is felt to have reduced large wood, the major impact due to forest management has probably been due to roading. Road densities in subwatersheds range from 2.2 to 6.3 miles per square mile, with numerous roads within riparian reserves. In addition to the roads there are numerous old skid roads. These old skid roads are often "opened" by recreationists as off road routes. Due to roads and past skidding activity, 20 percent of the watershed is estimated to be compacted. While there is no quantitative sediment data for the watershed there appears to be high risk of accelerated fine sediment delivery due to erosion of road surfaces **(**MacDonald et al 1999**)**. The large road network, both classified roads and unclassified roads, especially those roads near streams, allows recreation vehicle access to stream banks. Recreation use is contributing to loss of in-channel wood and streambank erosion. Another effect of past timber harvest is a change in the forest structure. Partial cutting prescriptions in the 1930's-1960's removed dominate overstory trees leaving stands of shade tolerant species. The past harvest combined with fire suppression has resulted in over-stocked, dense stands prone to catastrophic fire (MacDonald et al 1999).

Taneum-Manastash Watershed

Logging began in the Taneum watershed in the 1930's with the construction of a railroad up Taneum Creek. In the Manastash watershed logging began in the late 1950's. Selective harvest was the primary silviculture prescription until the late 1960's when clearcutting became a more common practice in the watershed. Above and below the National Forest boundary, timber harvest and other development has impacted 20 and 30 percent of the watershed, respectively. (USDA 1995). The watershed is also heavily roaded with the Taneum watershed having a road density of 5.25 miles per square mile, North Fork Taneum watershed 2.51 miles per square mile, South Fork Taneum 1.12 miles per square mile, and the Manastash watershed at 2.82 miles per square mile. Past logging and associated road construction are felt to be contributing to loss of in-channel woody debris, loss of off-channel habitat and some bank instability (Mayo 1999).

Ahtanum Watershed

Timber harvest along streams has reduced large woody debris recruitment, canopy cover and bank stability. Some road segments are contributing fine sediment into streams (WDNR 1998).

Teanaway Watershed

Logging began in the Teanaway watershed around the turn of the century. Railroad lines were built up the mainstem and larger tributaries. The logs were moved by rail and splash damming the streams. The past activity caused bank and channel erosion, reduced large woody debris and canopy cover. In more recent times, roads have been built throughout much of the middle and lower portions of the drainage. Many segments of the road system contribute fine sediment to the stream system. Timber harvest along streams has also reduced canopy cover and large woody debris recruitment. Additionally, logging activity has substantially increased on private lands in the middle portion of the basin. Roughly 23,000 acres of land has been approved for timber harvest on private land in the past two years. The effects of the elevated timber harvest, road use, road building and ground disturbance on the local bull trout population needs to be evaluated and addressed.

Little Naches Watershed

Past forest practices, including road construction, has likely contributed to degraded habitat in the Little Naches with construction of the 1900 road having a large impact. The Little Naches River, Crow Creek, and Bear Creek are on the 303(d) list for temperature. Riparian harvest may have contributed. Fine sediment in spawning gravel has been annually sampled in the watershed since 1991. Fine sediment levels have ranged between 12 and 20 percent depending upon the reach. While the watershed can be expected to be naturally prone to fine sediment delivery, timber harvest, roads and dispersed recreation are felt to be contributing. In 1992, 215 miles of road were surveyed in the watershed, 55 percent were determined to have potential for sediment delivery to streams, with 20 percent showing evidence of actively delivering fine sediment. Since then road improvements (improved drainage, surfacing, stabilizing cut slopes) and road obliteration have been completed on approximately one-half the problem road segments. In the past 3-4 years fine sediment in spawning gravels has been on a downward trend (Dawson 1999).

Riparian roads, timber harvest, and recreational activity has reduced in-channel woody debris and had a major effect on wood loading in the Little Naches River. Prior to the period of intensive timber harvest and road construction (1966-1975), flows in the Little Naches were comparable to those in the American River. However, after intensive timber harvest and road construction (1981-1994), flows in the Little Naches are higher than those in the American for the same period.

Tieton River

The Upper Tieton watershed, above Rimrock Dam is in relatively good condition, although timber management has likely impacted tributaries to the Lower Tieton such as Wildcat, Milk and Oak Creek drainages (MacDonald et al 1998a). Timber harvest has occurred within riparian reserves along a few tributary streams such as Short and Dirty Creek, Pinegrass, Grey and Cold creeks. There has been some recent timber harvest within riparian reserves including approximately four miles in the headwaters of the South Fork Tieton subwatershed, almost two miles in the lower South Fork Tieton subwatershed and approximately three miles in the Fish, Spencer, Short and Dirty watersheds (MacDonald et al 1998b). Much of the dry and mesic forest types within the watershed have had timber harvest and there is some evidence of a change in the timing of peak flows. Most of the timber harvest has been overstory removal often with tractor logging. There is no quantitative fine sediment data for the Upper Tieton. A large natural slide (Blue Slide) contributed a large amount of sediment to the South Fork Tieton. The extent to which timber harvest contributes additional sediment is not known and is further masked by apparent increased sediment due to grazing and recreation use (MacDonald et al 1998b).

Livestock Grazing

Watersheds within the recovery unit have a long history of grazing going back to the 1800's. Cattle and sheep numbers have been greatly reduced. Overall in the recovery unit, USFS lands are believed to be recovering from historic grazing. Overall within the recovery unit grazing is not of a great concern with a couple of exceptions being the Ahtanum, Teanaway, Lower and Upper Tieton watersheds.

Ahtanum Watershed

Cattle grazing has caused eroding stream banks and accelerated sediment delivery to Ahtanum Creek. Cattle trampling bull trout redds is another concern in this watershed (Anderson, E. in litt. 2001b).

Teanaway Watershed

Some areas in the Teanaway have had substantial effects from cattle grazing. Eroding banks and accelerated sediment delivery have been observed along several tributaries to the North Fork Teanaway including Jungle, Jack, Indian, Middle, Dickey and Lick Creeks. Much of the mainstem of the North Fork Teanaway also has grazing effects. Past and recent grazing may be limiting the establishment of riparian vegetation along some stream reaches, thereby elevating stream temperatures.

Lower and Upper Tieton

Other than a recent observation in Oak Creek, no bull trout have been found in tributaries to the lower Tieton. Impacts to aquatic habitat from grazing within the lower Tieton is a concern in the Oak Creek drainage (off the USFS lands), Soup Creek, upper Wildcat Creek and Milk Creek (MacDonald et al 1998). Vegetation in the Soup Creek drainage has been altered by a long history of ungulate grazing, both cattle and elk. Range conditions have been improving over the last 30-40 years from a very poor condition but can still only be rated as poor-fair. Prior to cattle turn-out riparian vegetation is approaching forest plan standards. The area is however an elk calving area. Elk graze the area hard in the spring and Forest plan utilization standards are not met prior to cattle entering the pasture. Fish Flats, between Soup and Haus creeks is another area of concern. Cattle are now being re-routed in an attempt to allow regrowth of grass to forest plan standards following heavy utilization by elk. Cattle also graze an approximately 10 acre unit adjacent to a tributary to Wildcat Creek. Cattle are now herded upslope away from the sensitive riparian habitat in Milk Creek (MacDonald et al 1998).

Grazing is also a concern in the Upper Tieton watershed. Of particular concern is over utilization of Minnie Meadows and Conrad Meadows adjacent to the South Fork Tieton. Total utilization in meadows is 73 percent (57 percent by elk and 16 percent by cattle). Minnie Meadows has been fenced but cattle were still able to get into the meadow in 1999. Further administrative action is proceeding with the permitted to keep cattle away from the meadow and South Fork Tieton. Problems in Conrad Meadows are primarily associated with private land and unauthorized use on USFS lands.

Agricultural Practices

Bull trout within the Yakima basin are adversely affected by irrigation diversions and water withdrawals. Unscreened or inadequately screened irrigation diversions strand bull trout (and other fish) in irrigation canals, sometimes resulting in high mortality. In addition, water withdrawals from streams for irrigation, particularly in late summer, exacerbate natural low-flow conditions and in some streams such as Ahtanum Creek result in total dewatering. Low flows in late summer can prevent bull trout, which are preparing to spawn from reaching spawning grounds and can strand them. Low stream flows can also strand rearing juvenile fish in dry channel beds. Low flows can also result in elevated water temperatures which can delay spawning. When irrigation water is returned to streams and rivers, it carries sediment and non-point pollution from agricultural chemicals which degrade water quality. Specific watersheds of concern include, but are not limited to, the Teanaway River and Taneum and Manastash creeks.

Certain reaches in both the upper and lower Yakima River do not comply with Washington State Department of Ecology (WDOE) standards for temperature, fecal coliform, sediment, and pesticide residue, and have been placed on the Section 303(d) list of the Clean Water Act. Turbidity and phosphorus have also been detected at concentrations that may affect aquatic life. There is a fish consumption advisory for resident fish taken from the Yakima River from its mouth to just above Yakima, and for some lower river tributaries, due to high herbicide levels in resident fish tissue samples (Johnson et al 1986). The National Water Quality Assessment Program conducted a pilot study in 1990, which indicated that fish, benthic invertebrate, and algal communities in the lower Yakima River and some tributaries were compromised, and concluded the ecological health in these stream reaches was impaired (Cuffney et al. 1997).

Recently, State, Federal, and Tribal agencies, irrigation entities, and individuals in the Yakima River Basin have initiated programs and projects to begin correcting some of the water quality problems. Water conservation projects are intended to be a primary means of improving water quality. Some of the irrigation districts have implemented water quality monitoring programs and policies with the goal of meeting State water quality standards for irrigation return flows. Total Maximum Daily Load standards for suspended sediments in the Yakima River are to be met within 5 years (WDOE 1997). Water temperature is also a water quality constituent of concern. During the summer, water temperatures in the lower Yakima River become lethal for salmonids (Vaccaro 1986).

Mining

Historically mining occurred in much of the recovery unit. There is a limited amount of small-scale suction dredging and hard rock mining still occurring in several watersheds including the Little Naches, and Cle Elum. By far the most mining activity both past and present is in the Swauk watershed.

Swauk Watershed

The Swauk watershed has a long history of mining. Historic mining activity has resulted in dredging and diking the stream, loss of large wood and possibly accelerated sediment delivery. Mining remains a significant land use in the watershed. There is some hard rock mining but other than an operation near the confluence with First Creek most of the current mining activity consists of small-scale suction dredging (MacDonald et al 1999). Small-scale suction dredging can be harmful to eggs or alevins. Suction dredging can also impact fish habitat by increasing turbidity, removal of wood, bank excavation, and changes to the substrate. Small-scale suction dredging in Washington is regulated by the State under “Rules and Regulations for Mineral

Prospecting and Placer Mining in Washington State" also known as "Gold and Fish"(WDFW 1999). Revisions to Gold and Fish regulation in 1999, included timing restrictions which may decrease the impact to bull trout eggs or alevins. The regulations also include management practices designed to protect habitat. The level of compliance with the "Gold and Fish" management practices is not known. Harvey et al (1995) state the individual effects of suction dredge operations should be small and confined to a site. What is not known are the cumulative impacts on habitat and aquatic biota in streams with many operations.

Residential Development and Urbanization

Specific areas within the Yakima River basin have grown in popularity as a preferred area for home sites. As the population increases more impacts to riparian areas and water quality are likely. Future impacts may include increases in nutrient loading from septic systems, chemical applications, and additional road construction. Increased compliance monitoring is needed to assess the effects of this development and determine if state, county and tribal management plans are being followed. Areas of particular concern are Lower Little Creek and the Naches River.

Fisheries Management

Harvest

Relatively little is known about the harvest impacts on bull trout in the Yakima basin. Existing angler catch records, some of which date back to the 1930's show few bull trout harvested relative to other species. Due to the random and non-standardized fashion most catch information was collected it is useful only for showing the presence of bull trout in a particular stream and possibly their relative abundance compared to other species. Although bull trout were observed in creel checks, they were probably targeted by relatively few anglers, in part, due to their lower abundance and because they were not as highly regarded as other game fish.

Although angling impacts and harvest are not known, they may have been significant in some areas of the basin. Large fluvial and adfluvial bull trout were easily harvested from spawning areas prior to the implementation of restrictive fishing regulations in the mid-1980's. The fish were easily observed, hooked, or snagged in the small clear water streams where they spawned.

Hatcheries

It is likely that negative impacts to bull trout also resulted from stocking large numbers of catchable-sized hatchery rainbow into Yakima basin streams during the 1960's to early 1980's (e.g., Ahtanum, Naches, Tieton/Rimrock and Teanaway drainages). Impacts included competition for food and space, predation on bull trout juveniles, and increased harvest by anglers. Although most angler effort was directed at catching stocked trout, the incidental catch and harvest of bull trout likely occurred at a higher rate as well. The use of bait and barbed treble hooks by anglers fishing for other species (e.g., rainbow, cutthroat trout) also increased the hooking mortality of incidentally caught and released bull trout. The combination of hatchery-stocked rainbow, large catch limits, the use of bait and easy public access to main stem and tributary streams generated high angling pressure that probably had negative impacts on the wild bull trout stock.

In addition to general harvest impacts in the Yakima basin, poaching has been identified as a serious concern in Gold Creek (Keechelus Lake tributary), Box Canyon Creek (Kachess Lake tributary), Deep Creek (Bumping Lake tributary), South Fork Tieton River and Indian Creek (Rimrock Lake tributaries). It is not known how much of a problem poaching may be for other Yakima basin bull trout populations. The combination of easy public access to the spawning grounds and the early migration of adult spawners into the streams during the high summer recreational-use period compounds the problem.

Kokanee and rainbow trout fry have been periodically stocked into the large upper basin reservoirs (Cle Elum, Kachess, Keechelus, Rimrock and Bumping Lakes) since the 1930's. In recent years only cutthroat (westslope strain) and kokanee fry have been stocked. Although natural reproduction of kokanee occurs in some tributary streams, it is limited. Severe fluctuations in reservoir levels affect kokanee spawning success, abundance and growth. Supplemental fry stocking has probably benefitted bull trout by providing an increased forage base. Kokanee and juvenile trout serve as important forage for adult bull trout rearing in the reservoirs.

Currently, the WDFW is working with the Yakama Nation to supplement wild spring chinook and to reestablish self-sustaining populations of coho in the Yakima River sub-basin. A hatchery facility was constructed at Cle Elum with several acclimation ponds in the upper basin. It is generally felt that this supplementation program will not impact bull trout stocks and will likely benefit bull trout and other resident fish. Historically, bull trout probably benefitted from the presence of anadromous salmonids. The downstream drift of eggs released from spawning salmon provided food for bull trout and other resident fishes, but more importantly the presence of decaying salmon carcasses greatly benefitted juvenile salmon and resident fishes thru nutrient recycling. Generally, in drainages colonized by natural anadromous salmon and steelhead populations the bull trout have successfully co-existed. However, in many areas where bull trout currently exist, habitat conditions have deteriorated and natural predator-prey balances have been upset. Bull trout populations are at or near critically low levels in many areas of the basin. For this reason, caution should be exercised in stocking large numbers of hatchery fish near bull trout spawning and rearing areas to avoid the potential for competition or predation on bull trout fry.

Introduced Non-Native Species

A wide range of non-native species have been introduced into the Yakima basin including brook trout, lake trout, brown trout, bass, catfish, bluegill, sunfish, and crappie. Warm water species like bass and catfish were originally introduced into the lower Yakima River in the early 1900's. Cold water salmonid species like brook and lake trout were introduced into the upper basin in the mid 1900's. Although non-native species are no longer stocked in main stem river areas where there is the potential to interact with native species they have become established in many areas of the basin with self-sustaining naturally reproducing populations. Probable impacts to bull trout include predation on juveniles and competition for food and space.

Brook trout may also pose a serious genetic threat to bull trout due to the potential for hybridization. Since the resulting offspring are fertile it provides an avenue for further introgression with bull trout populations. Currently, there are naturally reproducing populations of brook trout throughout the upper Yakima and Naches River basin. Notable brook trout concentrations exist in the Cle Elum and Waptus lake drainages, the upper Yakima River between Easton and Keechelus lakes, and small tributary streams of the Naches (e.g., Milk Creek) and upper Yakima (e.g., Taneum, Manastash creeks). Although brook trout are prevalent in the basin it does not appear that widespread hybridization has occurred as they are seldom observed in or near bull trout spawning areas. To date, only one hybrid has been verified through genetic analysis in the basin. However, few samples have been collected from areas throughout the basin to determine the extent of hybridization. Waptus Lake, in the upper Cle Elum drainage, may be at risk of extirpation due to brook trout colonization. Recent fisheries surveys in the Waptus Lake drainage indicate a healthy naturally reproducing population of brook trout.

Other non-native species introduced into the basin include brown trout and lake trout. Brown trout were discovered in Cooper Lake (upper Cle Elum River) in 1987. Apparently this species was illegally introduced, probably in the late 1970's. Fisheries surveys conducted in Cooper Lake in 1995 confirmed a wide range of sizes of brown trout, suggesting that natural reproduction is occurring. In 1996, brown trout were also discovered in the lower Waptus River.

Lake trout were probably stocked into Cle Elum Lake before 1933. Although these fish are reproducing in the lake, they do not appear to be abundant. However, few anglers have targeted lake trout, and consequently it is difficult to estimate their abundance based on current catch data. The species certainly has the potential to compete with, or prey on, bull trout. Lake trout are said to have been stocked into Kachess and Keechelus lakes before 1933, but the introduction was probably unsuccessful, and there are no data that confirm the presence of lake trout in either lake.

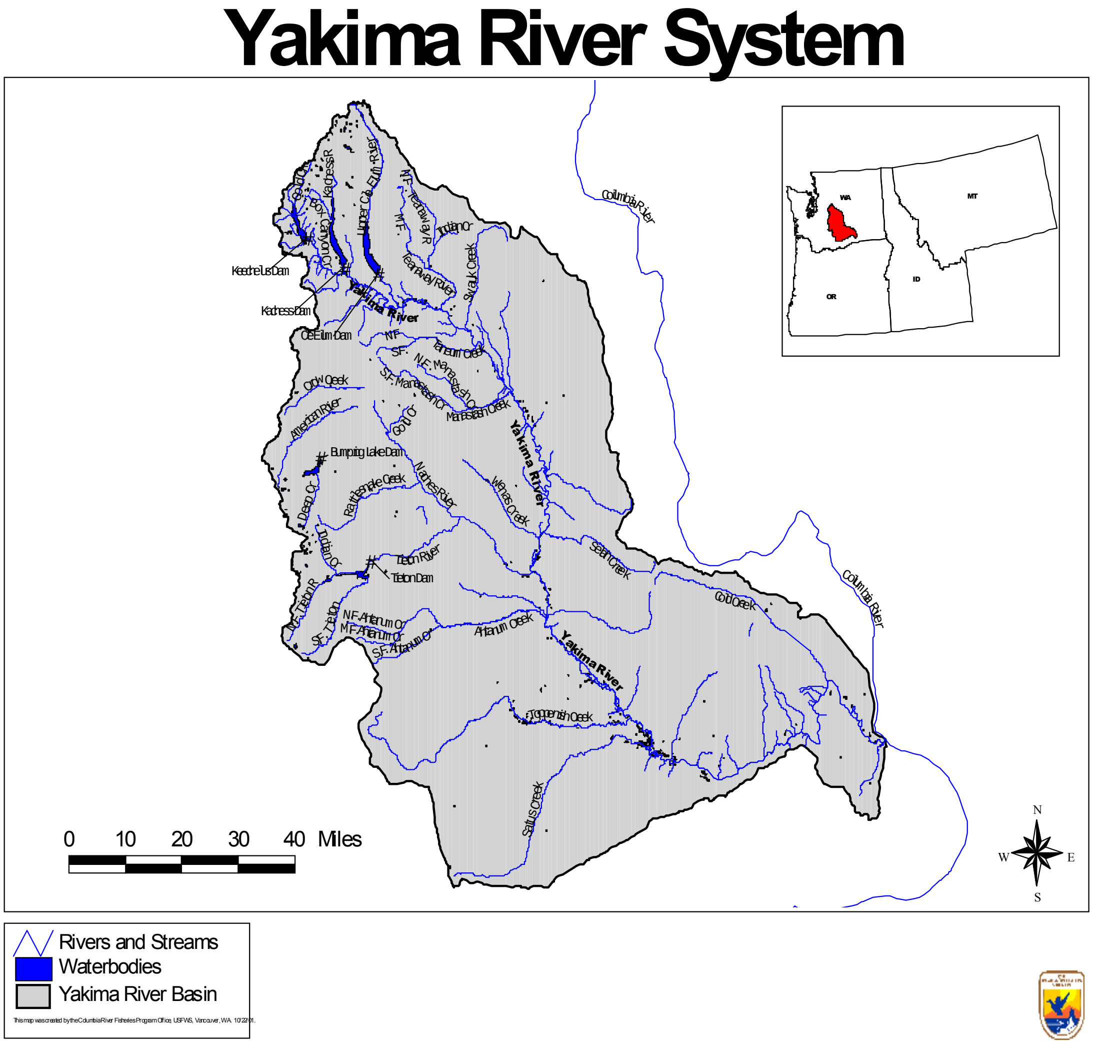

Figure 1. Yakima River system and important tributaries.

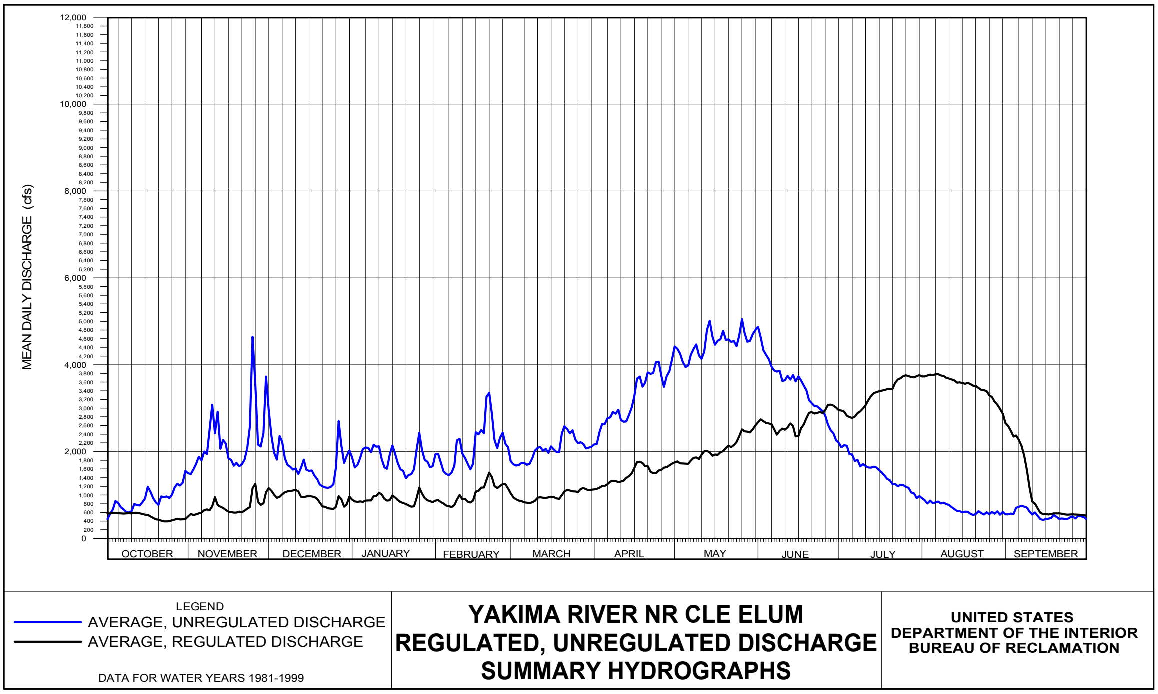

Figure 2. Hydrograph for the Yakima River at the Cle Elum gaging station (1981-1999).

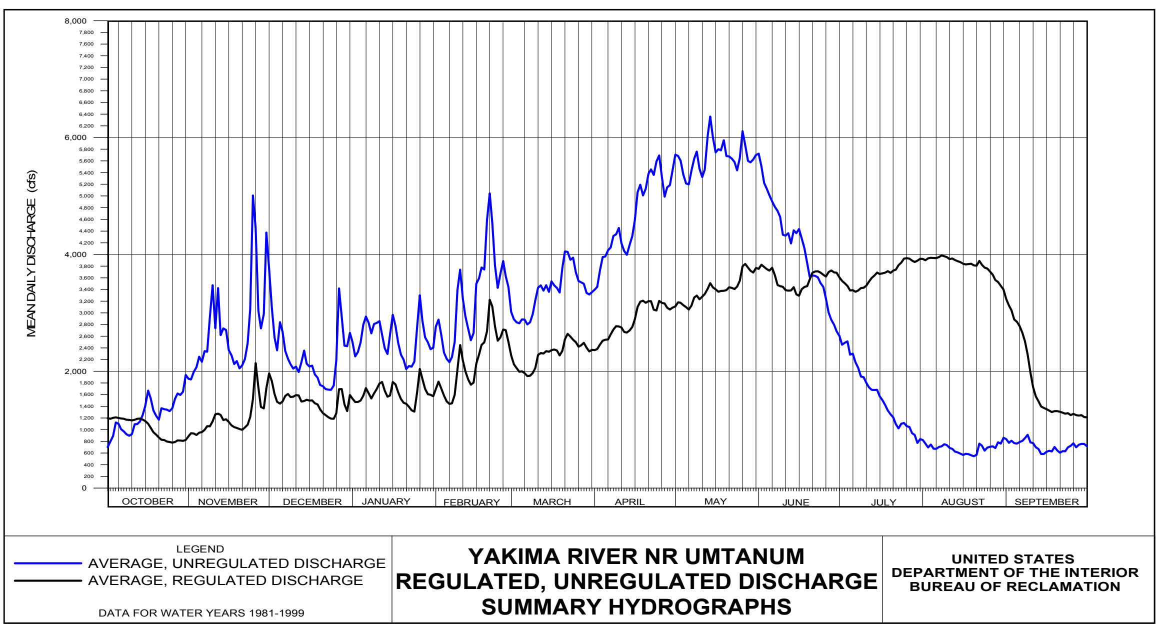

Figure 3. Hydrograph for the Yakima River at the Umtanum gaging station (1981-1999).

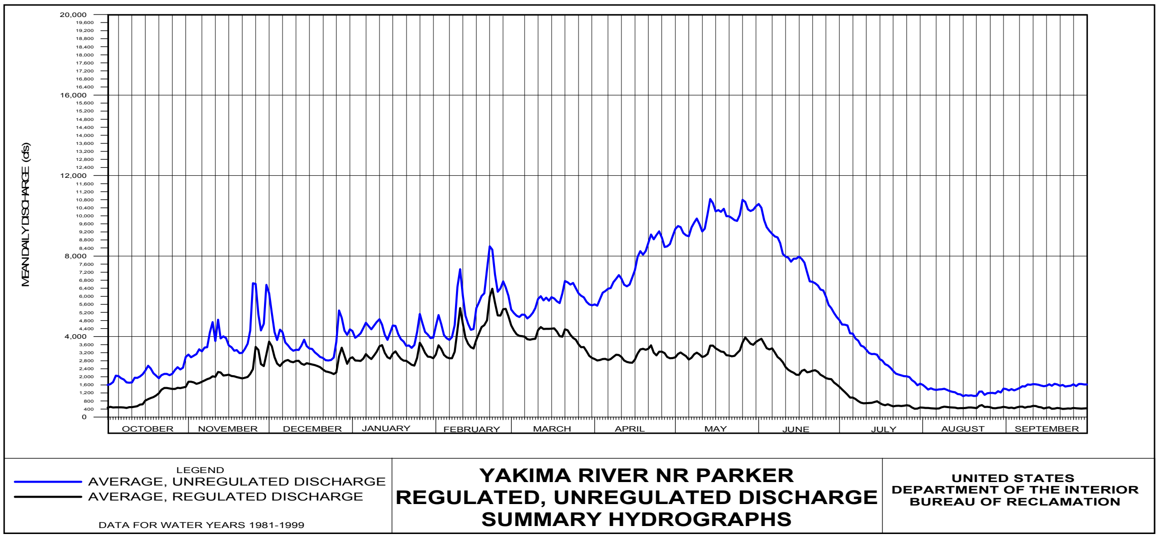

Figure 4. Hydrograph for the Yakima River at the Parker gaging station (1981-1999).

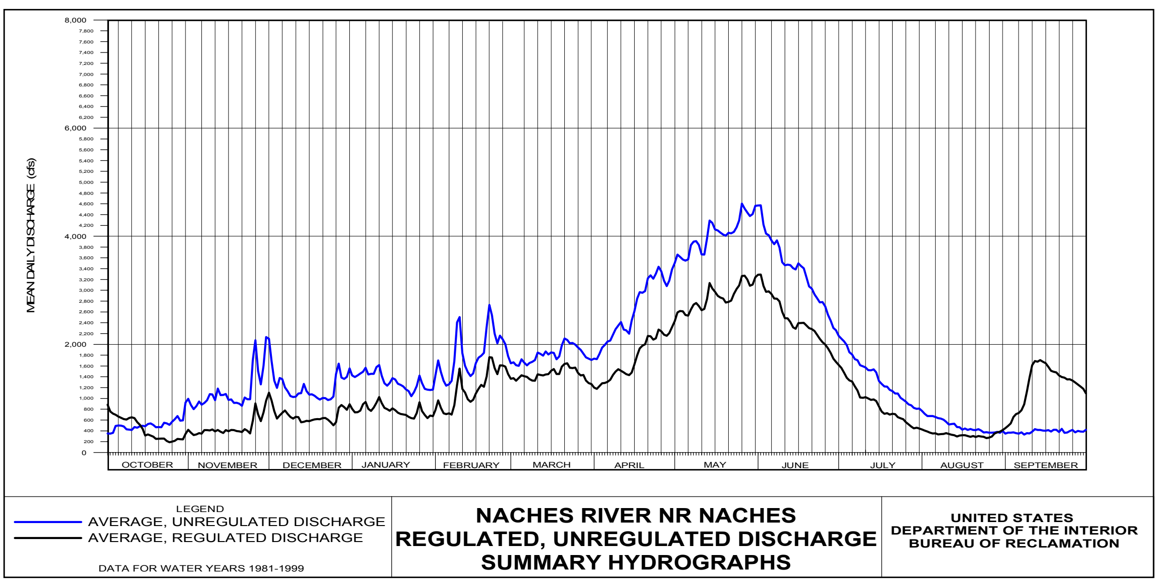

Figure 5. Hydrograph for the Naches River near haches, WA (1981-1999).

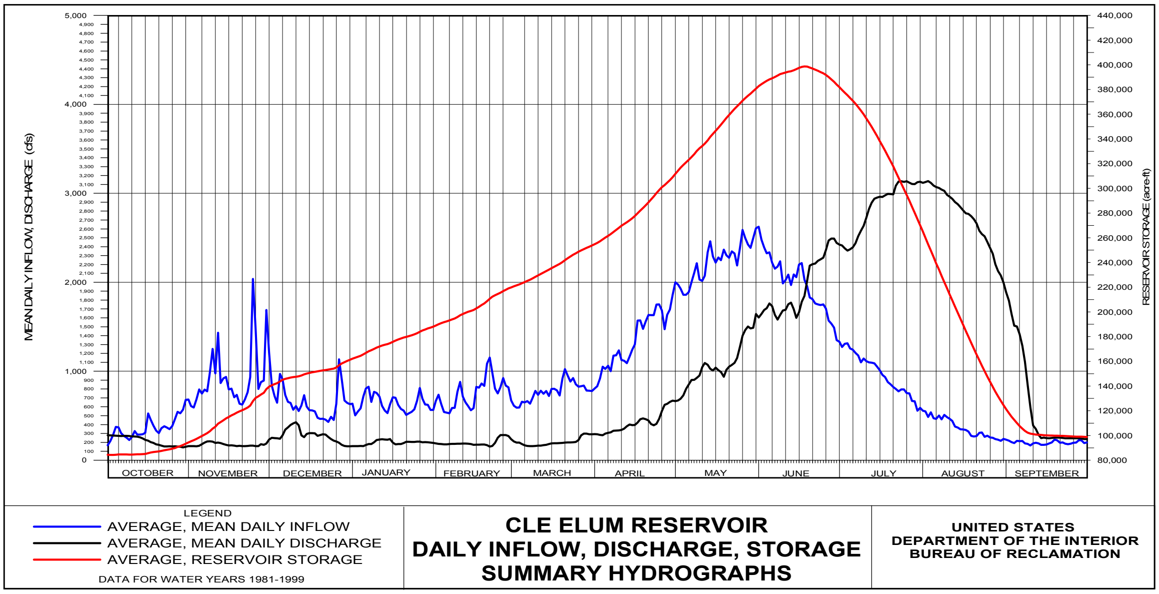

Figure 6. Hydrograph for the Cle Elum River in the upper Yakima Basin (represented by the discharge plot on the graph) from 1981-1999.

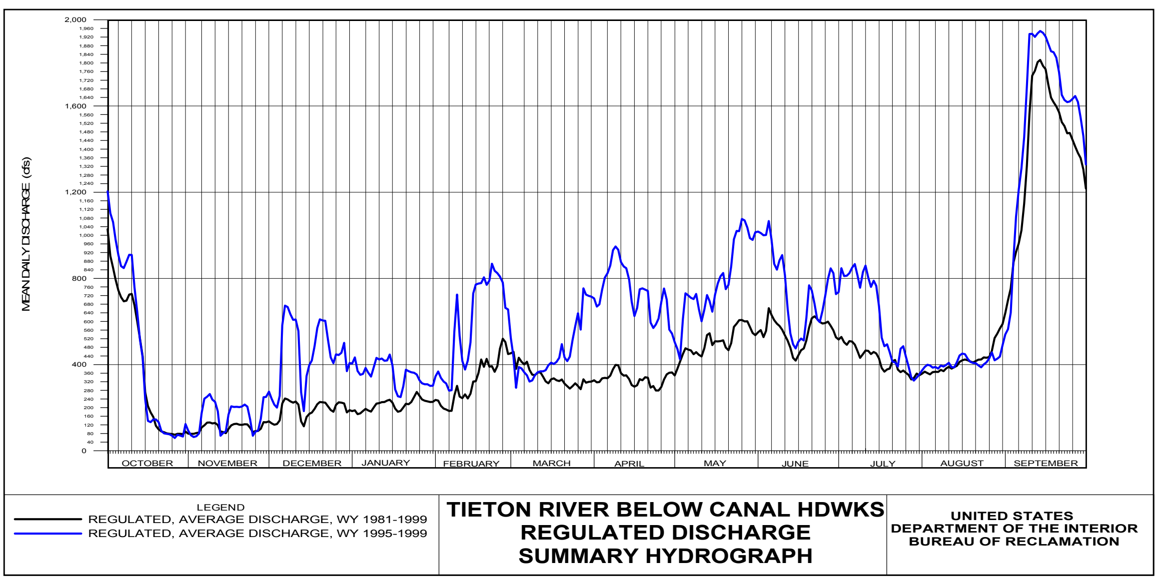

Figure 7. Hydrograph for the Tieton River below Yakima-Tieton Irrigation District's headworks from 1981-1999 (only regulated streamflow data are available at this site).

References Cited

Baxter, C.V., C.A. Frissell, and F.R. Hauer. 1999. Geomorphology, logging roads, and the distribution of bull trout spawning in a forested river basin: implications for management and conservation. Transactions of the American Fisheries Society 128:854-867.

Baxter, J.S., and J.D. McPhail. 1999. The influence of redd site selection, groundwater upwelling, and over-winter incubation temperature on survival of bull trout (*Salvelinus confluentus*) from egg to alevin. Canadian Journal of Zoology 77:1233-1239.

Boag, T.D. 1987. Food habits of bull char, *Salvelinus confluentus*, and rainbow trout, *Salmon gairdneri*, coexisting in a foothills stream in northern Alberta. Canadian Field-Naturalist 101:56-62.

Bonneau, J.L, and D.L. Scarnecchia. 1996. Distribution of juvenile bull trout in a thermal gradient of a plunge pool in Granite Creek, Idaho. Transactions of the American Fisheries Society 125:628-630.

Brown, L.G. 1992. On the zoogeography and life history of Washington native charr Dolly Varden (*Salvelinus malma*) and bull trout (*Salvelinus confluentus*). Washington Department of Wildlife, Fisheries Management Division Report, Olympia, Washington.

Buchanan, D.M., and S.V. Gregory. 1997. Development of water temperature standards to protect and restore habitat for bull trout and other cold water species in Oregon. Pages 1-8 *in* W.C. Mackay, M.K. Brewin and M. Monita, editors. Friends of the Bull Trout Conference Proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Calgary, Alberta, Canada.. Friends of the bull trout conference proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Calgary, Canada.

Cuffney, T.F., M.R. Meador, S.D. Porter, and M.E. Gurtz. 1997. *, 1990.* USGS Water Resources Investigations Report 96-4280.

Dawson. 1999. Biological assessment for steelhead, bull trout and cutthroat trout for the proposed actions in the Little Naches watershed. USDA Forest Service, Wenatchee National Forest, Naches Ranger District. January 29, 1999.

Donald, D.B., and D.J. Alger. 1993. Geographic distribution, species displacement, and niche overlap for lake trout and bull trout in mountain lakes. Canadian Journal of Zoology 71: 238-247.

Dunham, J. B. and G. L. Chandler. 2001. Models to predict suitable habitat for juvenile bull trout in Washington State. Final Report, USFS, Rocky Mountain Research Station.

Fraley, J.J., and B.B. Shepard. 1989. Life history, ecology and population status of migratory bull trout (*Salvelinus confluentus*) in the Flathead Lake and River system, Montana. Northwest Science 63:133-143.

Gamett, B. 1999. The history and status of fishes in the Little Lost River drainage, Idaho. Salmon-Challis National Forest, Idaho Department of Fish and Game, U.S. Bureau of Land Management, Sagewillow, Inc. May 1999 draft.

Goetz, F. 1989. Biology of the bull trout, *Salvelinus confluentus*, literature review. Willamette National Forest, Eugene, Oregon.

Harvey, B. C., T. E. Lisle, T. Vallier, D.C. Fredley. 1995. Effects of suction dredging on streams: a review and evaluation strategy. Report to Gray Reynolds, deputy chief National Forest System, USDA Forest Service. September 29, 1995.

Hoelscher, B., and T.C. Bjornn. 1989. Habitat, density and potential production of trout and char in Pend Oreille Lake tributaries. Project F-71-R-10, Subproject III, Job No. 8. Idaho Department of Fish and Game, Boise, Idaho.

Jakober, M. 1995. Autumn and winter movement and habitat use of resident bull trout and westslope cutthroat trout in Montana. M.S. Thesis, Montana State University, Bozeman, Montana.

Johnson, A., D. Norton, and B. Yake. 1986. Occurrence and Significance of DDT Compounds and Other Contaminants in Fish, Water and Sediments From the Yakima River Basin. Washington Dept. of Ecology, Olympia WA.

Leathe, S.A., and P. Graham. 1982. Flathead Lake fish food habits study. Environmental Protection Agency, through Steering Committee for the Flathead River Basin Environmental Impact Study.

Lohr, S., T. Cummings, W. Fredenberg, and S. Duke. 1999. Listing and recovery planning for bull trout. U.S. Fish and Wildlife Service publication. Boise, Idaho. www.r1.fws.gov/crfpo

MacDonald, K. 1999. Cle Elum watershed aquatic species environmental baseline. USDA Forest Service, Wenatchee National Forest, Cle Elum Ranger District. January 1999.

MacDonald, K., D. Driscoll, J. Leingang, S. Hoefer. 1998a. Fisheries biological evaluation on-going activities Lower Tieton Watershed. USDA Forest Service, Wenatchee National Forest, Naches Ranger District. June 3, 1998.

MacDonald, K., J. Leingang, S. Hoefer. 1998b. Fisheries biological evaluation, on-going activities Upper Tieton Watershed. USDA Forest Service, Wenatchee national forest, Naches Ranger District. June 11, 1998.

MacDonald, K and T. Mayo 1999. Yakima watershed steelhead, bull trout westslope cutthroat trout watershed biological assessment. USDA Forest Service, Wenatchee National Forest, Cle Elum Ranger District. March 3, 1999.

MacDonald, K., B. Ehinger, S. Carter, K. Kelly. 1999. Swauk watershed fish biological assessment on-going management activities. USDA Forest Service, Wenatchee National Forest, Cle Elum Ranger District. April 1999.

Mayo, Tina. 1999. Taneum-Manastash watershed aquatic species biological assessment for new and on going projects. USDA Forest Service, Wenatchee National Forest, Cle Elum Ranger District. August 26, 1999.

Pratt, K.L. 1985. Pend Oreille trout and char life history study. Idaho Department of Fish and Game, Boise, Idaho.

Pratt, K.L. 1992. A review of bull trout life history. Pages 5 - 9 *in* P.J. Howell, and D.V. Buchanan, eds. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon.

Pratt, K.L., and J.E. Huston. 1993. Status of bull trout (*Salvelinus confluentus*) in Lake Pend Oreille and the lower Clark Fork River: (draft report) Prepared for the Washington Water Power Company, Spokane, Washington.

Ratliff, D.E., and P.J. Howell. 1992. The status of bull trout populations in Oregon. Pages 10-17 *in* P.J. Howell. and D.V. Buchanan, eds. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon.

Rich, C.F., Jr. 1996. Influence of abiotic and biotic factors on occurrence of resident bull trout in fragmented habitats, western Montana. M.S. Thesis, Montana State University, Bozeman, Montana.

Rieman, B.E. and J.D. McIntyre. 1993. Demographic and habitat requirements for conservation of bull trout. United States Department of Agriculture, Forest Service, Intermountain Research Station, General Technical Report INT_302, Ogden, Utah.

Rieman, B.E., and J. D. McIntyre. 1995. Occurrence of bull trout in naturally fragmented habitat patches of varied size. Transactions of the American Fisheries Society 124:285-296.

Rieman, B.E., D.C. Lee and R.F. Thurow. 1997. Distribution, status and likely future trends of bull trout within the Columbia River and Klamath River basins. North American Journal of Fisheries Management 17:1111-1125.

Sedell, J.R., and F.H. Everest. 1991. Historic changes in pool habitat for Columbia River Basin salmon under study for TES listing. Draft U.S. Department of Agriculture Report, Pacific Northwest Research Station, Corvallis, Oregon.

Sexauer, H.M., and P.W. James. 1997. Microhabitat use by juvenile trout in four streams located in the eastern Cascades, Washington. Pages 361-370 *in* W.C. Mackay, M.K. Brewin and

M. Monita, editors. Friends of the Bull Trout Conference Proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Calgary, Alberta, Canada.

Simpson, J.C., and R.L. Wallace. 1982. Fishes of Idaho. University Press of Idaho. Moscow, Idaho.

Spence, B.C.,G. Lomnicky, R. Hughes, R. Novitzki 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6057. Management Technology December 1996

SOAC. 1999. Report to the Secretary of the Interior. System Operations Advisory Committee for the Yakima Project (U.S. Bureau of Reclamation).

Swanberg, T. 1996. The movement and habitat use of fluvial bull trout in the upper Clark Fork River drainage. M.S. Thesis, University of Montana, Missoula, Montana.

Thomas, G. 1992. Status of bull trout in Montana. Report prepared for Montana Department of Fish, Wildlife and Parks, Helena, Montana.

USFWS (U.S. Fish and Wildlife Service) 1998. Klamath River and Columbia River bull trout population segments:status summary. Prepared by the Service's bull trout listing team.

USBR (U. S. Bureau of Reclamation) 1999. Programmatic Environmental Impact Statement. Yakima River Basin Water Enhancement Project, Washington. 1999. U.S. Department of Interior, Bureau of Reclamation.

USDA 1995 Taneum-Manastash watershed analysis. USDA Forest Service, Wenatchee National Forest, Cle Elum Ranger District.

Vaccaro, J.J. 1986. Simulation of Streamflow Temperatures in the Yakima River Basin, Washington, April-October 1981. U.S.G.S. Water Resources Investigations Report 85-4232. Tacoma WA.

WDNR (Washington Department of Natural Resources) Southeast Region. 1998. Ahtanum Watershed Analysis covering the Darland Mountain, Foundation and Cowiche Watershed Administrative Units. 203 pp. Olympia, WA.

WDFW (Washington Department of Fish and Wildlife) 1999. Gold and Fish: Rules and Regulations for Mineral Prospecting and Placer Mining in Washington State.

WDFW (Washington Department of Fish and Wildlife) 1998. Washington State Salmonid Stock Inventory- Bull Trout/Dolly Vardin.

WDOE (Washington Dept. of Ecology). 1997. A Suspended Sediment and DDT Total Maximum Daily Load Evaluation Report for the Yakima River. Pub No. 97-321, Olympia WA.

Watson, G., and T.W. Hillman. 1997. Factors affecting the distribution and abundance of bull trout: and investigation at hierarchical scales. North American Journal of Fisheries Management 17:237-252.

In Litt.

Anderson, E. in litt. 2001a. E-mail received from Eric Anderson, WDFW on July 25, 2001. Subject: Bull trout distribution in the Yakima basin.

Anderson, E. in litt. 2001b. E-mail received from Eric Anderson, WDFW on July 25, 2001. Subject: Bull trout distribution in the Yakima basin.

Anderson, E. in litt. 2001c. E-mail received from Eric Anderson, WDFW on October 23, 2001. Subject: Bull trout distribution in the Upper Cle Elum and Yakima rivers.

Pers. Comm.

Lindhorst, K. personal communication, 2001. Conversation with Ken MacDonald, USFS, June 2001. Subject: Documentation of bull trout in the Bumping River.

Werdon, S., Fish and Wilflife Service, *per. comm.* 1998. Notes from the *Salvelinus confluentus* Curiosity Society workshop, Jarbidge River.